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Short Note

Preliminary observations suggest Common Myna prefer lipid over protein and carbohydrate foods in a pairwise choice experiment

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Common Mynas *Sturnus tristis*, previously known as *Acridotheres tristis*, are considered among the world's worst most invasive species. However, relatively little is known about the factors that affect their persistence and spread in new environments. They have been observed feeding on a wide range of foods, including anthropogenic foods in urban areas. Their diet preferences are relatively unknown. Therefore, we investigated the macronutrient preferences of Common Mynas in captivity. Common Mynas (*n* = 10) were given a pairwise choice of three different diets (high lipid, high protein, and high carbohydrate diets) in the laboratory to determine their preference. Common Mynas showed a preference for the high lipid food, followed by high protein, with the high carbohydrate food least preferred. Consequently, this suggests Common Mynas preferred food high in lipids compared with proteins and carbohydrates, but additional study is needed to confirm this. Implications are Common Mynas should not be a problem for South African agricultural areas, because this industry generally provides relatively few dietary items high in fat, so we expect the Common Myna will continue to be distributed mainly in urban areas of South Africa where anthropogenic foods relatively high in fat are more common.

Des observations préliminaires suggèrent que le Martin triste préfère les aliments riches en protéines et en glucides dans une expérience de laboratoire

Les Martins triste *Sturnus tristis*, connues auparavant sous le nom d'*Acridotheres tristis,* font partie des pires espèces les plus invasives du monde. Cependant, on sait relativement peu de choses sur les facteurs qui influent sur leur persistance et leur propagation dans de nouveaux environnements. Ils ont été observés en train de se nourrir d'un large éventail d'aliments, y compris d'aliments anthropiques en milieu urbain. Leurs préférences alimentaires sont relativement inconnues. Par conséquent, nous avons étudié les préférences en macronutriments des Martins tristes en captivité. Nous avons donné à des martins tristes (*n* = 10) élevés en laboratoire le choix de sélectionner trois régimes différents (régimes riches en lipides, en protéines et en glucides) pour déterminer leur préférence. Les Martins ont montré une préférence pour les aliments riches en lipides, suivis des protéines, avec les aliments riches en glucides les moins préférés. Par conséquent, cela suggère que les martins tristes préfèrent les aliments riches en lipides par rapport aux protéines et aux glucides, mais des travaux supplémentaires sont nécessaires pour le confirmer. Les implications suggèrent que ces martins ne devraient pas être un problème pour les zones agricoles sud-africaines car cette industrie fournit généralement relativement peu d'aliments diététiques riches en matières grasses. Nous nous attendons donc à ce que le martin triste continue à être distribué principalement dans les zones urbaines d'Afrique du Sud où les aliments anthropiques sont relativement riches en gras sont plus fréquents.

Keywords: alien invasive, dietary preference, macronutrients, urban exploiters

Common Mynas (*Sturnus tristis,* previously known as *Acridotheres tristis*) are omnivorous, invasive birds, native to southern Asia (Baker and Moeed 1987; Peacock et al. 2007; Lowe et al. 2011; Haythorpe et al. 2014). These passerine birds are considered amongst the most invasive species worldwide (Holzapfel et al. 2006; Peacock et al. 2007; van Rensburg et al. 2009). They have invaded many countries, including South Africa (Baker and Moeed 1987; Peacock et al. 2007). Common Mynas live in a close association with humans and thrive in urban areas (Griffin and Boyce 2009; Lowe et al. 2011; Haythorpe et al. 2014). They are also able to endure different environmental and climate conditions (Baker and Moeed 1987; Peacock et al. 2007). In other countries, flocks of Common Mynas are known to damage fruit (grapes and citrus fruits) crops (Baker and Moeed 1987; Machovsky-Capuska et al. 2016). Furthermore, Common Mynas are known to compete with native species for resources, such as nesting sites and food, posing a threat to native species (Peacock et al. 2007; Lowe et al. 2011; Haythorpe et al.

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2014; Machovsky-Capuska et al. 2016). They have been observed feeding on a large range of foods (seeds, nectar, food scraps, bread and everything they find in trash bins) and human refuse (Peacock et al. 2007; Machovsky-Capuska et al. 2016). As members of the Sturnidae, Common Mynas provide a good model system to study nutritional limitations (Machovsky-Capuska et al. 2016) and their role in this successful invader.

Birds' diets are influenced by many factors, including their morphology and physiology (Nicolson and Fleming 2014). Avian feeding guilds include nectarivores, frugivores, insectivores, and omnivores though many species switch diet depending on food availability (Levey and del Rio 2001; Voigt et al. 2008; Nicolson and Fleming 2014). This variation in birds' diet preference results in their having differing digestive and nutrient absorption (Levey and del Rio 2001). Nutrients found in fruits and nectar are different from those found in insects and require different digestive mechanisms (Levey and del Rio 2001). Urban birds, specifically Common Mynas, have been observed feeding on a range of anthropogenic foods (Machovsky-Capuska et al. 2016). In this study, we examined the macronutrient preference of Common Mynas in the laboratory when offered a pairwise choice of different foods varying in specific macronutrients (high protein, high lipid, and/or high carbohydrate), but with similar energy yields. We predicted that Common Mynas would show a significant preference for the high protein food, as found in an Australian study of Common Mynas (Machovsky-Capuska et al. 2016).

Ten Common Mynas were captured in an urban area habitat of Pietermaritzburg, KwaZulu-Natal, South Africa (29°35′23.9″ S, 30°23′59.9″ E) in April 2015 and in July 2016, using mists nets under permit from Ezemvelo KZN Wildlife. During this time, birds were provided with the maintenance diet, as well as the three experimental foods, so that they may acclimatise to experimental foods. Birds were fed a maintenance diet that consisted of grated fruit and vegetable mix, slices of pawpaw, bananas and oranges supplemented with Aviplus Softbill Myna Pellets (Aviproducts Durban, South Africa). After the outdoor acclimatisation, birds were moved inside the animal house to a constant environmental room temperature, kept individually in cages (77 × 52 × 81 cm) and acclimated for a week before experiments. During this time, they were provided the maintenance diet daily, as well as the three experimental diets for them to be familiar with diets before experiments began.

Pairwise choice tests were conducted using three experimental foods: high protein vs high lipid, high protein vs high carbohydrate, and high lipid vs high carbohydrate. These macronutrients were chosen, because they are typical of urban anthropogenic food resources (Machovsky-Capuska et al. 2016; CT Downs, pers. obs.). The high protein food was achieved by using two Aviplus products (Aviproducts, Durban, South Africa). Aviplus high protein fat concentrate (Table 1; 40% protein, 14% fat and also vitamins, minerals and trace elements) was supplied in a ground form, because it is usually added to birds' diet as a supplemental component. This was added to Aviplus parrot instant cooking mix dinner, which contains rolled and roasted (cooked) grains and peas. We increased the protein content of the latter to 28% by adding the Aviplus high protein fat concentrate (Table 1). The mixture was ground together before being offered to Common Mynas and the final food treatments looked similar.

The Sutherland's high fat parrot mix (Aviproducts, Durban, South Africa; lipids 20% of dry weight; contains peas, maize, wheat, palm oil, mixed nuts and sunflower seed mixed with parrot supplement; Table 1) was used as the high lipid food. Although it was premixed by the manufacturer, we ground it before feeding it to Common Mynas. The high carbohydrate food was prepared by adding brown sugar (sucrose) to the Aviplus parrot cooking mix dinner, which increased carbohydrate to 20% dry weight (Table 1), and ground before feeding it to Common Mynas. Although Common Mynas, like most other starlings, do not generally digest foods high in sucrose efficiently (Gumede and Downs 2019), we observed them feeding on anthropogenic waste foods high in sucrose so used it to supplement the carbohydrate in this diet. Consequently, the intention of adding sucrose was to produce mixes that reflected the general anthropogenic urban diet.

The respective choice experiments were conducted from 06h00 to 18h00. Common Mynas were weighed before and after each of the trials. The respective diets (50 g of each) were offered to Common Mynas in two separate bowls whose positions were changed at midday to avoid positional bias. Food consumption was measured each hour from 07h00 to 18h00 to ensure birds were eating. All ten birds were given the same pair choice of food during trials and each trial was run for one day. Trials were not run on consecutive days, one or two days were skipped before the next trial, and food was randomly place in each birds' cage. Total food consumption was calculated for each trial by subtracting food (in grams) left from initial food offered to the birds. The various parameters measured included body mass initially and finally, and hourly intake rates were compared using Repeated Measures Analysis of Variance (RMANOVA) with STATISTICA (Statsoft, Tulsa, United States). Dependent *t*-tests were used to test preference between diets in terms of total consumption.

The initial body mass of the Common Mynas did not differ significantly between the three different food trails (RMANOVA; $F_{(2, 18)} = 1.311$; $p = 0.294$), nor did their final body mass differ significantly between the respective trials (RMANOVA; $F_{(2, 18)} = 0.0$; $p = 1.0$). The mean initial body mass ranged from 96.6 to 99.6 g and mean final body mass was 101.0 g.

The hourly rate of consumption of the respective foods by Common Mynas differed significantly when offered the macronutrient foods: high protein versus high lipid (RMANOVA; $F_{(11, 99)} = 17.89$; $p < 0.05$; Figure 1a); high lipid versus high carbohydrate (RMANOVA; $F_{(11, 99)} = 17.263$; $p < 0.05$; Figure 1b), and high protein versus high carbohydrate (RMANOVA; $F_{(11, 99)} = 15.424$; $p < 0.05$; Figure 1c).

In terms of total consumption at the end of each experiment day, Common Mynas showed a significant difference in preference between high protein and high lipid foods (*t*-test; $p = 0.003$; $t = 5.415$; df = 18; Figure 2a); mean total consumption of the high lipid was higher than the high protein food (Figure 2a). There was also a significant difference in total consumption between the high protein

Table 1: Nutritional composition of the three diets offered to Common Mynas

Nutrient	Unit	Actual		
		High fat mix	High carbohydrate parrot cooking mix	High protein fat
Volume	None	100	100	100
Metabolisable energy	MJ kg^{-1}	16	0	15.9
Metabolisable energy poultry	MJ kg^{-1}	0	15.45	0
Crude protein	g kg^{-1}	165	124	396
Lysine	g kg^{-1}	7.3	5.72	21
A-Lysine	g kg^{-1}	6.4	0	0
Methionine	g kg^{-1}	4	1.88	9
TSAA	g kg^{-1}	6.7	4.06	15
Isoleucine	g kg^{-1}	6.5	4.43	18
Tryptophan	g kg^{-1}	1.8	1.07	4
Threonine	g kg^{-1}	5.6	4.3	15
Arginine	g kg^{-1}	12.3	8.11	0
Fat	g kg^{-1}	200	29.15	139
Fibre	g kg^{-1}	34	31.76	40
NDF	g kg^{-1}	65	0	108
Calcium	g kg^{-1}	6.2	0.42	10
Total phosphorus	g kg^{-1}	5	3.27	6
Available phosphorus	g kg^{-1}	3.2	0	3
Sodium	g kg^{-1}	1.4	0.13	2
Chloride	g kg^{-1}	1.9	0	4
Potassium	g kg^{-1}	6.5	0	12
Sulphur	g kg^{-1}	2.6	0	0
Magnesium	g kg^{-1}	2.2	0	0
Ash	g kg^{-1}	43.35	18.02	58
Histidine	g kg^{-1}	0	1.96	0
Valine	g kg^{-1}	0	5.84	0
Linoleic acid	g kg^{-1}	0	13.49	0
Carbohydrate	g kg^{-1}	0	580.8	0
Dry matter	g kg^{-1}	0	0	903
Digestable energy for swine	g kg^{-1}	0	0	16
Net energy for swine	g kg^{-1}	0	0	110
AS Lysine	g kg^{-1}	0	0	18
AS Methionine	g kg^{-1}	0	0	8
AS TSAA	g kg^{-1}	0	0	13
AS Isoleucine	g kg^{-1}	0	0	13
AS Tryptophan	g kg^{-1}	0	0	3
AS Threonine	g kg^{-1}	0	0	12
AS Valine	g kg^{-1}	0	0	15

and high carbohydrate foods (*t*-test; $p = 0.012$; $t = 5.960$; df = 18; Figure 2b); mean total consumption of the high protein food was higher than the high carbohydrate food (Figure 2b). There was a significant difference between the high lipid and the high carbohydrate foods (*t*-test; $p = 0.003$; $t = 6.716$; df = 18; Figure 2c); mean total consumption the high lipid food was higher than the mean total consumption of the high carbohydrate food (Figure 2c). Accordingly, Common Mynas showed a preference for the high lipid food in comparison to the other foods and high carbohydrate food was least preferred (Figures 2a, 2b and 2c).

Common Mynas showed a significant preference for a high lipid diet in comparison to high fat or high carbohydrates in this study when offered a pairwise choice of foods varying in macronutrients. Food selection in animal species is influenced by many factors, such as physiological, morphology and behavioural qualities (Bozinovic and Martinez del Río 1996; Klasing 1998; Avery et al. 1999; McWilliams et al. 2002; Caron-Beaudoin et al. 2013; Zungu and Downs 2016). The findings of recent studies differ from the results we present here: Machovsky-Capuska et al. (2016), using free-roaming birds, and Peneaux et al. (2017), using captured birds, found that Common Mynas in Australia showed a preference for proteins compared with lipids and carbohydrates. In both studies, different sources of lipids, proteins and carbohydrates were used. Common Mynas are mostly urban and/or associated with human habitation (Peacock et al. 2007; Griffin and Boyce 2009; Lowe et al. 2011; Haythorpe et al. 2014) and exposed to anthropogenic food sources (Caron-Beaudoin et al. 2013), which are generally made up of a range of different macronutrients (Machovsky-Capuska et al. 2016). The exposure of Common Mynas to anthropogenic foods may be of an advantage in enabling them to digest and assimilate different types of macronutrients. Additionally, Common Mynas are generalist omnivores with a varied range of feeding habits (Klasing 2005; Ríos et al. 2014) and are

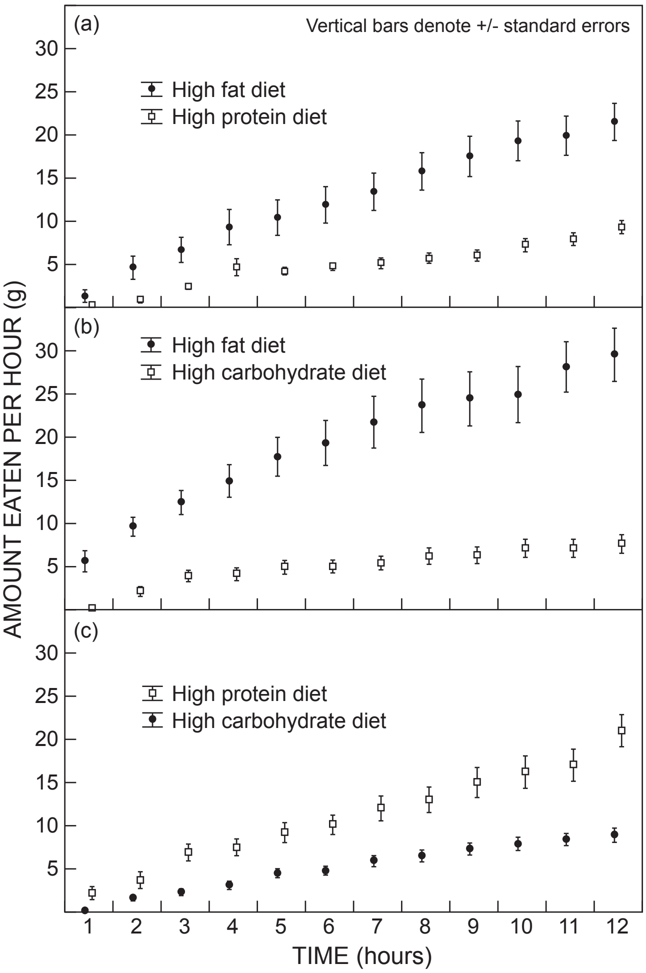

Figure 1: The mean hourly rate of food consumption of Common Mynas (n = 10 for all tests) when offered the respective macronutrient diets offered in pairwise choice tests where a) was high protein versus high lipid, b) high lipid versus high carbohydrate, and (c) high protein versus high carbohydrate

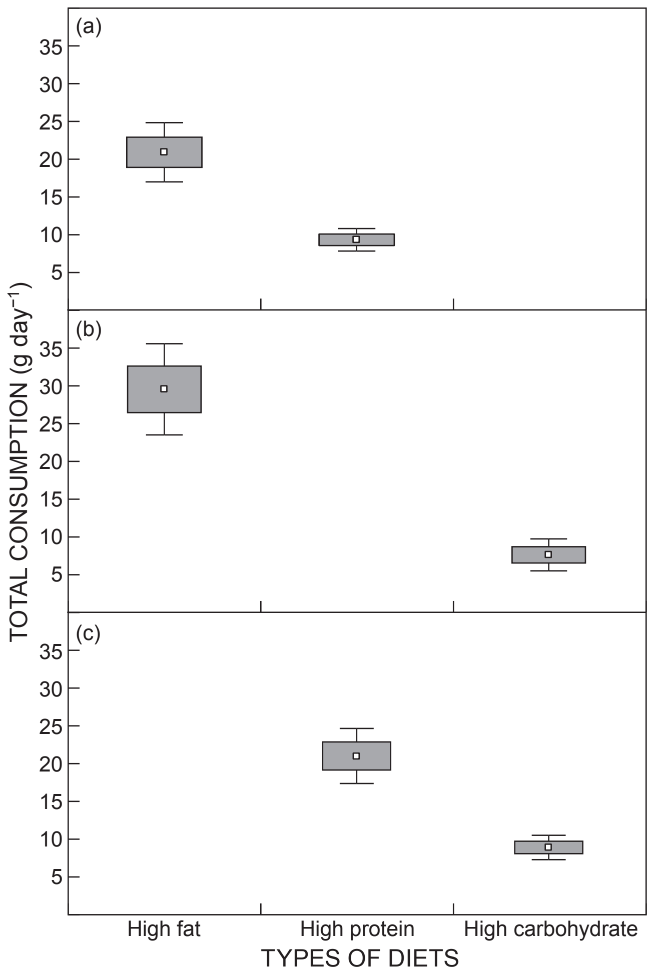

Figure 2: The total food consumption of the respective macronutrient diets offered in pairwise choice tests to Common Mynas (n = 10 for all tests), where a) was high protein versus high lipid, b) high lipid versus high carbohydrate, and (c) high protein versus high carbohydrate

able to thrive in a wide variety of environmental conditions and can make use of a variety of different food resources (Machovsky-Capuska et al. 2016).

Generally, fats are digested and absorbed into the system with relatively high energy returns (McWilliams et al. 2002; Pierce et al. 2004; Kim et al. 2013; Roura et al. 2013). Specifically, unsaturated fatty acids may be absorbed more efficiently (Pierce et al. 2004). There is a direct relationship between nutrients and taste (Roura et al. 2012); however, ingestion of certain nutrients may be influenced by seasons or conditions (Ríos et al. 2014). During cold conditions birds store large amounts of fats in their bodies (McWilliams et al. 2002). In our study, weather conditions were excluded by the laboratory setting with a controlled environment.

Furthermore, food availability influences the feeding behaviour of birds (Bozinovic and Martinez del Río 1996; Klasing 2005). In summer, most of the omnivorous birds feed on insects and switch to fruits in winter (Klasing 2005; Podlesak and McWilliams 2006). Insects are higher in proteins and fats, but have less carbohydrate (Voigt et al. 2008). Therefore, it is not surprising that Common Mynas preferred lipids and proteins to carbohydrates in this study. It is clear that different avian species differ in their choice and ability to absorb nutrients from their respective diets.

Nectarivores and frugivores consume mainly simple carbohydrates, namely sucrose, glucose and fructose (Brown et al. 2010a; Bizaaré et al. 2012). Generally, granivorous and omnivorous birds react negatively to sugars (Roura et al. 2013). In this study, carbohydrates were the least preferred nutrient to Common Mynas. As members of the Sturnidae, Common Mynas were expected not to prefer carbohydrates (Gatica et al. 2006; Brown et al. 2012). Generally, the Sturnidae members are unable to digest sucrose efficiently, because they lack the enzyme sucrase responsible for digestion of sucrose (Gatica et al. 2006; Bizaaré et al. 2012; Brown et al. 2012). Preference of simple sugars is related to the efficiency and degree to which these simple sugars are assimilated (Bozinovic and Martinez del Río 1996). This behaviour has been observed in several other avian species, such as the

Common Starling (*Sturnus vulgaris*) (del Rio et al. 1988), the American Robin *Turdus migratorius* (Karasov and Levey 1990), the Red-winged Starling *Onychognathus morio* (Bizaaré et al. 2012), the Austral Thrush *Turdus falcklandii*, and the Chilean Mockingbird *Mimus thenca* (Gatica et al. 2006). In our study, Common Mynas showed dietary flexibility, but showed the least preference for the carbohydrate high diet, which was relatively high in sucrose. However, the maintenance diet, which consisted of fruit and vegetables may have affected the lack of preference for the high carbohydrate/sucrose food, which differed from the findings of Peneaux et al. (2017).

Managing invasive avian species that exhibit dietary flexibility, such as Common Mynas, is a challenging task. In South Africa, Common Mynas have invaded the eastern part of the country and the distribution is extending towards south and west of the country. The southwestern region of South Africa extensively produces wine and deciduous fruit (Kaplan and Kaplinsky 1999; Bruwer 2003). In other countries, Common Mynas damage fruit crops (grapes and citrus fruit) (Baker and Moeed 1987). However, in South Africa there is currently no evidence that Common Mynas damage fruit crops. Therefore, their potential negative impact on agriculture in South Africa cannot be confirmed at this point. The results of this study indicate that Common Mynas are likely less of a problem for commercial fruits relatively high in sucrose. However, invasive animals are highly adaptable, and may fill unoccupied niches where competition is low (Mason et al. 2005). Furthermore, Common Mynas have been mostly invading urban areas rather than natural or rural habitats in South Africa (SABAP 2 2018). For invasive species to successfully invade new environments, they must be able to exploit novel food resources that consist of different macronutrients. In this study Common Mynas showed dietary flexibility that may enhance their foraging behaviour in new environments. Additional field-based experiments are required on how dietary flexibility contributes to invasiveness of Common Mynas.

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